CHAPTER 20
HYDROLOGIC AND HYDRAULIC ANALYSIS

20. INTRODUCTION

The technical guidance for this chapter has primarily been taken from Applied Hydrology by Chow, Maidment and Mays, Hydrologic Analysis and Design by Richard McCuen, Handbook of Hydraulics 7th Edition by Brater, King, Lindell and Wei, Open Channel Hydraulics by Terry Sturm, assorted technical papers by Arthur Miller, Ph.D., P.E. on hydrologic analysis and assorted technical papers by Danny Fread, Ph.D. on dam failure analysis.

21. HYDROLOGY REPORT

A hydrology report shall be submitted for the construction of all new high and significant hazard dams as well as evaluation of existing high and significant hazard dams to meet dam safety program requirements during a formal inspection (if a report hasn't already been prepared). The report shall contain the following:

___ The report shall be signed, sealed, and dated by the Mississippi Registered Professional Engineer responsible for its development in a manner consistent with the requirements of the State Board of Registration for Professional Engineers and Land Surveyors, as they apply generally to the practice of engineering. The hydrologic analysis and report may also be done by a registered professional hydrologist, however all design and recommendations that affect public safety must be performed by or under the direct supervision of a Mississippi Registered Professional Engineer.

___ A description of the drainage basin which includes the name of the stream impounded and/or discharged to, the county the basin is located in, a physical description of the basin's characteristics as they affect runoff, soil type(s) using SCS names, SCS hydrologic group(s) and curve number(s), the amount of urban development present as well as a 5 year projection of urban development, size of the drainage area in square miles or acres and average slope of the basin.

___ A topographical map showing scale, name of USGS quadrangle map from which it was produced, outline of drainage area and sub-basins (if any), longest flow path from basin boundary to point of concentration (used for calculating time of concentration), the dam, the area that will be submerged at normal pool, outline of area submerged at maximum pool if dam is a flood control structure with low normal pool, downstream area and any development, section, range and township where lake is located and name and outline of stream impounded and/or discharged to.

___ A description of the design storm(s) used with the amount of inches of rainfall in a 24 hour period shown (refer to Dam Safety Regulation LW-4, Section IV, A, B, and D). For analysis of the principal spillway capacity of High Hazard dams, the 100-year, 24 hour storm event must be modeled using the SCS Type II or Type III dimensionless design

storm distribution. Analysis of the Probable Maximum Precipitation (PMP) design storm must use the dimensionless design storm distribution as shown in the regulations (SCS Emergency Spillway Hydrograph) or SCS Type II or Type III dimensionless design storm distribution. If the drainage area is larger than 10 square miles then the areal adjustments may be used. (See Page 6 & 7)

___ The method and calculations used to calculate time of concentration must be shown.

___ The program used to do the hydrologic analysis shall be named and all inputs and assumptions listed as well as the outputs. The equation method used to determine the peak discharge shall be stated (Note – the Rational Method shall not be accepted). A summary shall be included which states the peak inflow for each design storm, the time to peak, the volume of inflow to the reservoir, the volume of available storage, the capacity of the principal spillway when the auxiliary spillway activates as well as the maximum capacity of the principal spillway, the capacity of the auxiliary spillway and the maximum elevation of the pool for each design storm evaluated.

___ The runoff flow (in cfs) into the proposed impoundment versus time shall be plotted and the volume under the curve stated.

___ The storage volume and surface area of the impoundment versus elevation shall be plotted with the elevation of the dam toe (where zero storage occurs), the normal pool elevation, the auxiliary spillway crest elevation and the crest of the dam shown on the chart.

___ If augmentation for dry years or initial filling is considered in the design then the primary source shall be from surface water source(s). Groundwater augmentation to fill and/or maintain water levels shall be reviewed on a case by case basis and only allowed for special circumstances.

22. HYDRAULIC REPORT

The hydraulic analysis is usually done using the same program that is used for the hydrologic analysis. Required information may be provided in the same report as the hydrologic analysis and is acceptable where provided on the same output printout as the hydrologic analysis. The report shall contain the following:

___ A description of the principal and auxiliary spillways.

___ A plan and profile sketch of the principal and auxiliary spillways showing dimensions and elevations of the invert, outlet, control section, slope of spillway, crest of the dam and toe of the dam. The sketch shall show the location of the spillways in relation to the dam and the outlet channel.

___ The hydraulic equations (weir, orifice, culvert or gate) used for determining discharge shall be shown along with all coefficients used. If the spillway is a culvert(s) then the governing flow condition assumed shall be stated.

___ The stage-storage-discharge or stage-discharge relationship shall be plotted. If principal spillway is a riser and conduit configuration, then the elevation where full conduit flow develops shall be shown.

___ The velocity for open channel spillways (chute spillways and vegetated earthen spillways) shall be computed and shown as well as where flow transitions from sub-critical to critical to super-critical. Control section shall be placed where flow passes through critical depth.

___ Exit velocity or tractive forces for vegetated earthen spillways shall be computed. Type of vegetation shall be described. Earthen spillways should be cut through natural ground around the abutment of the dam. Earthen spillways that must go through fill or easily erodible soils shall be armored. Exit velocity for a vegetated earthen spillway shall not exceed the permissible velocities shown on the attached table from the USDA-SCS Engineering Field Manual.

___ Froude number shall be calculated for exit velocity at end of spillway(s) (flow entering hydraulic jump) for large dams (see Section 10.2). The depth after the jump shall be calculated and the stilling basin sized based on calculated depth (USBR recommends that length be approximately 6 times the calculated depth). A description of the stilling basin and a sketch showing dimensions and elevations shall be provided. For small and medium dams standard stilling basin guidelines (NRCS, COE, DEQ planning manual for storm water, etc.) are acceptable.

23. BREACH ANALYSIS

A breach analysis and inundation mapping shall be done for all high and significant hazard dams.

___ The method of breach analysis shall be based on lake size (see Section 10.2) unless special circumstances dictate otherwise. For small lakes breach analysis shall be by overtopping. For medium lakes breach analysis shall be by overtopping and sunny day failure (piping) at normal pool. For large lakes the breach analysis shall be sunny day failure at crest of auxiliary spillway.

___ The report shall be signed, sealed, and dated by the Mississippi Registered Professional Engineer responsible for its development in a manner consistent with the requirements of the State Board of Registration for Professional Engineers and Land Surveyors, as they apply generally to the practice of engineering. Nothing herein is to be construed as allowing any such work to be performed other than by or under the direct supervision of a Mississippi Registered Professional Engineer.

___ A description of the reservoir and downstream area which includes the name of the stream impounded and/or discharged to, the volume of the reservoir, the dam and the material (soil type) that it is constructed of, whether or not there is a core in the dam, the height of the dam and elevations for the toe, normal pool and crest, the county (and municipality if reservoir will impact a municipality) the reservoir is located in and a physical description of the downstream area including the amount and type of development present and key elevations shall be provided.

___ The method and calculations used to determine the breach formation factors (time of breach, size of breach) must be shown.

___ The program used to do the breach analysis shall be named and all inputs and assumptions listed as well as the outputs. A map shall be included showing and identifying the downstream cross sections (identify by labeling with the same number as in the program). An electronic copy of the project file shall be submitted along with the written report.

___ Comprehensive surveys of the downstream area for the purposes of establishing cross sections, unless the breach analysis is for the purpose of requesting a lower hazard classification, are at the discretion of the engineer preparing the analysis as to whether they are necessary. Elevations for cross sections may generally be obtained from U.S.G.S. quadrangle maps. More accurate data, such as GIS mapping from LIDAR data with 1 or 2 foot contours, or survey data, if easily obtainable, is recommended.

24. INUNDATION MAPPING

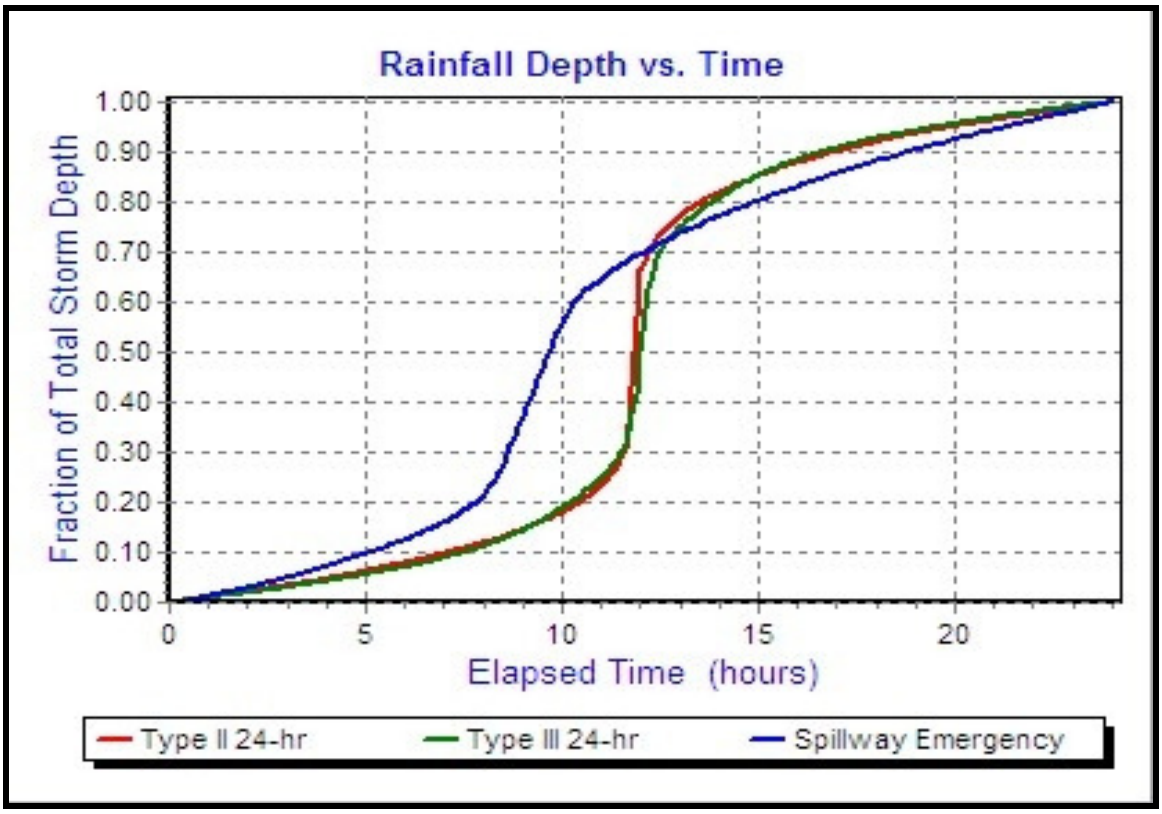
An inundation map shall be provided along with the breach analysis *unless* the breach analysis is for the purpose of proving that the dam is not a high or significant hazard.

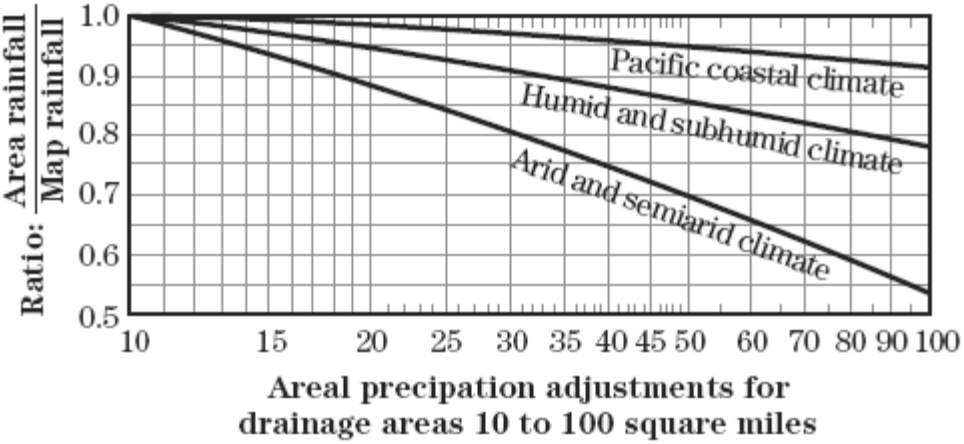
___ Map shall be in color and shall be at a scale where lake and impacted structures downstream may be clearly seen. If inundation area is too large to be shown on one map then an index map shall be included which shows the full extent of the inundation area and the outline of the detailed maps with an identifier for each map sheet. Outline of inundation area shall be marked in permanent ink in a color that is easily distinguishable. If inundation area is marked with hatching, then hatching will be done in such a manner as to not obscure impacted structures, roads and identifying labels.

___ Identifying features shall be clearly labeled (main roads, subdivisions, commercial complexes, etc.) so as to aid emergency responders in quickly locating impacted areas and conducting evacuations.

___ Suggested evacuation routes should be included and be marked with a direction arrow so as to assist emergency responders in directing evacuees to safety.

___ Travel times shall be marked on the map with increments no less than 20 minutes. Dams where everything downstream that will be impacted, will be impacted within the first hour, do not require travel times to be marked on the map.





Areal precipation adjustments for drainage areas 10 to 100 square miles

SCS Emergency Spillway Distribution

Time (hrs)	0	0.5	1	1.5	2	2.5	3	3.5	4
Fraction of Total Depth	0	0.004352	0.012838	0.021543	0.030535	0.04	0.050158	0.061078	0.072761
	4.5	5	5.5	6	6.5	7	7.5	8	8.5
	0.085207	0.098416	0.112387	0.127209	0.143542	0.16215	0.184215	0.215628	0.276613
	9	9.5	10	10.5	11	11.5	12	12.5	13
	0.369615	0.466104	0.556392	0.616503	0.646957	0.673827	0.697429	0.718308	0.737594
	13.5	14	14.5	15	15.5	16	16.5	17	17.5
	0.755792	0.772899	0.788923	0.804083	0.818563	0.832469	0.84583	0.858646	0.870918
	18	18.5	19	19.5	20	20.5	21	21.5	22
	0.882657	0.893946	0.904816	0.915348	0.925576	0.935579	0.945364	0.954931	0.964281
	22.5	23	23.5	24					
	0.973412	0.982367	0.991213	1					